Karst & Pseudo-karst Fieldtrip Notes

Date: May 27, 2005

Location(s): Met at 10:00 a.m. at parking lot Holiday Inn Bluefield, West Virginia, conducted field trip to several contamination sites and geological features of interest, and returned to starting point by 4:15 p. m.

Agenda:

10:00 am Meet at Bluefield Holiday Inn A. (see Field Map **Figure 1** for locations of "field stops").

10-11:00 Holiday Inn – Introductions; Karst and Pseudo-Karst Ground Water transport on Bluestone Watershed discussion; and map review.

11-12:15 Visit U.S. Highway 460 corridor sites…Holiday Inn Hole A., Cole Hole B., Beacon entrance (at Intermediate School); Beaverpond Resurgence C., which exits Beacon Cave system near Leatherwood Farms (Ordovician limestones); on way to restaurant, traveled down Washington Street (AEP sinkholes & Joy or Hart Electric Mfg site D.) to Cumberland Avenue to lunch.

12:30 – 1:20 Lunch in Bluefield E..

1:30 Morris Spring F. (Greenbrier Limestone); upon leaving traveled along U.S. Hwy 19 (a.k.a. Princeton Ave. and later becomes Bluefield Ave.),

1:50 Confluence of Whitley Creek and Beaverpond Creek G. (not on USGS maps) recent construction daylighted the stream to below the rail overpass and Bluefield VFD fire station. Portions of both Beaverpond and Whitley Creeks (including their confluence) were previously underground in Concrete Box construction.

2:30 Pocahontas Deep Mine Discharges (Poca 3 pseudo-karst). Did not get to H..

3:00 Road Cut showing limestone convolution at Pocahontas drinking water intake I. (located upstream of confluence of Abbs Valley River (fed by several springs including Big Spring) → Bluestone River).

3:30 PCB and Dioxin/Furan contamination site J. in Nemours

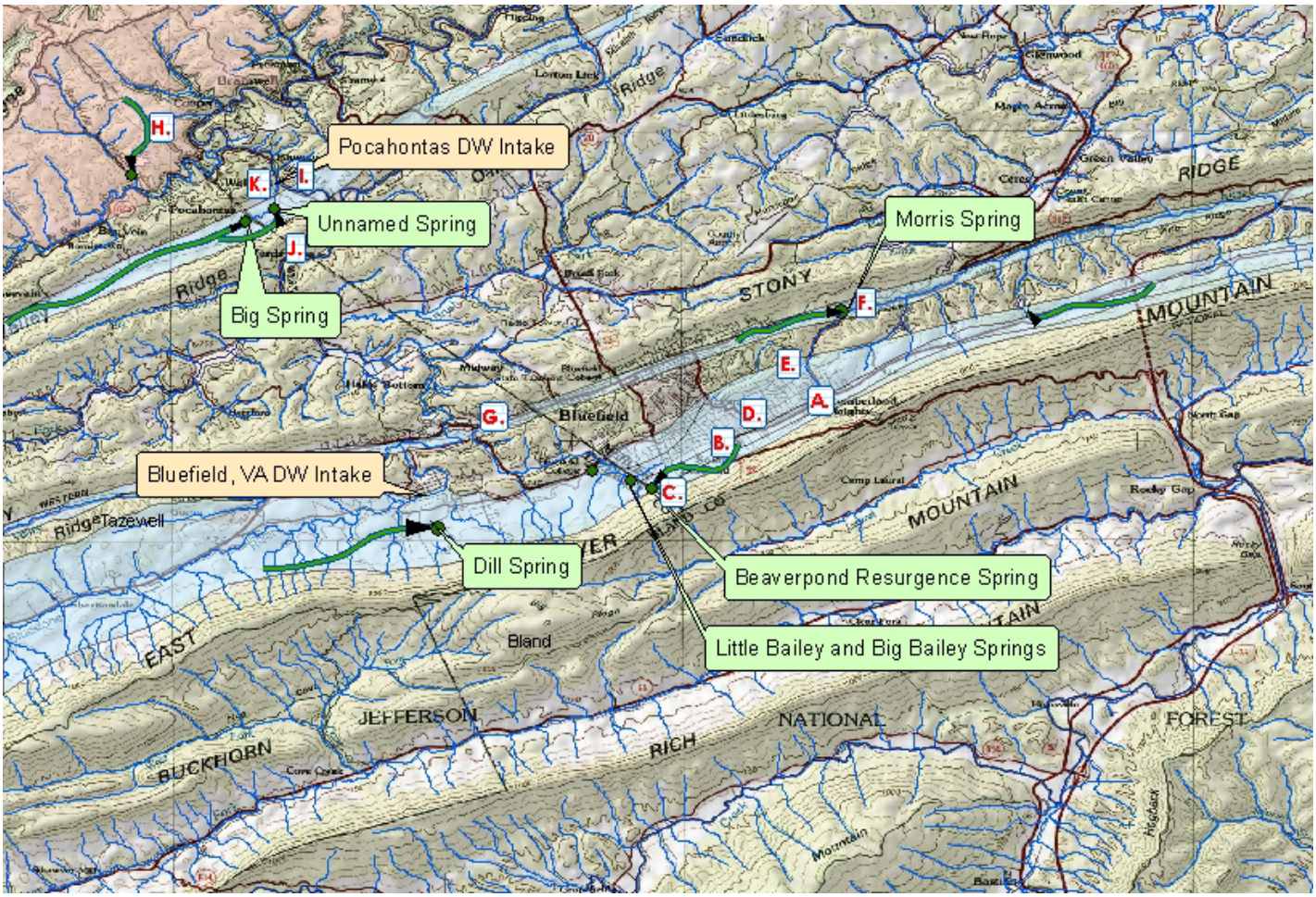
3:45 Nemours Country Store K. (Abbs Valley)

4:15 Return to Holiday Inn A.

Sixteen folks from various West Virginia and Virginia agencies and West Virginia University attended the field trip. After signing in, exchanging contact info., & making introductions, George Dasher, Nick Schaer, and Craig Lott discussed the purpose of our field trip, including a brief history of our investigations to date and several questions. We discussed current extent of knowledge of PCB-like contaminant transport in the watershed, and discussed briefly several drinking water issues. Electronic copies of George Dasher's handouts to include in this field trip summary and several maps and photos will be available at the following web links:

- **"Bluefield Area Field Trip**," by George Dasher, WVDEP (http://www.deq.virginia.gov/tmdl/pptpdf/bluetrip.pdf)
- **"Mercer County Groundwater and Karst"** by George Dasher**,** WVDEP (http://www.deq.virginia.gov/tmdl/pptpdf/mercerco.pdf)
- **"Various Photos Taken by Gracious Participants**" (http://www.deq.virginia.gov/tmdl/pptpdf/pcbpics.pdf)
- **original "PCB in the Bluestone River Study"** by Craig Lott, Allen Newman, et al. (http://www.deq.state.va.us/tmdl/pptpdf/blstpcb1.pdf)

Figure 1.
Karst Field Trip Sites of Significance (Including Referenced Field Stops).



Spring or Seep

Ground Water Flow

Limestone

Coal Mined Area

A. Selected Field Trip Sites (see Field Trip Agenda for site identification)

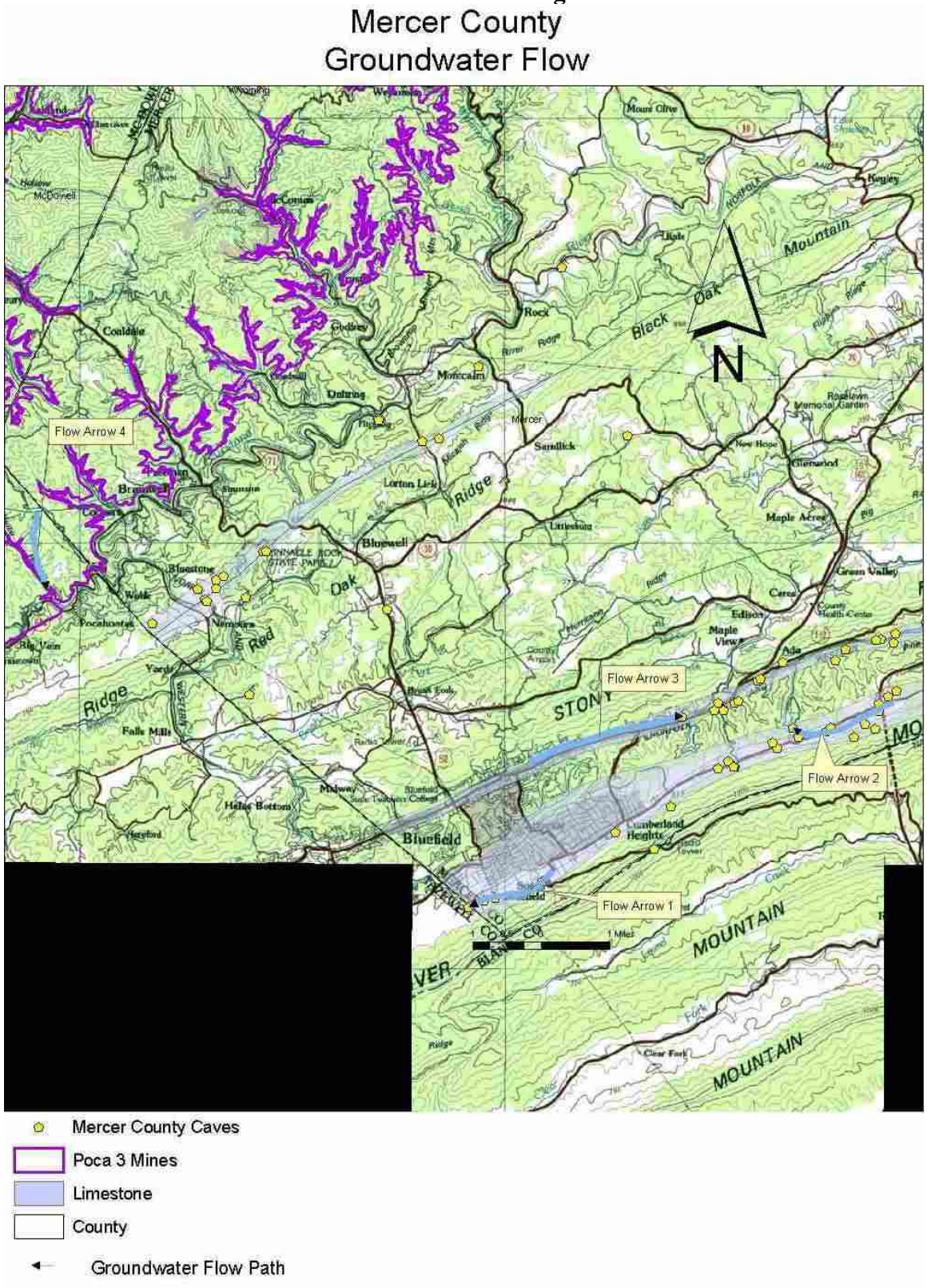
Terms and geologic formations of interest; Karst and pseudo-karst transport of PCB contamination in the Bluestone watershed

Karst – named from an area in Northern Yugoslavia, a type of topography that is formed over limestone, dolomite or gypsum where water movement occurs through naturally formed dissolution routes. Often associated with sinkholes, caves (e.g. Beacon Cave system and others), dry valleys (e.g. Abbs Valley and the WV portion of U.S. Hwy 460 corridor), resurgences (e.g. Beaver Pond Resurgence Spring and others), and sinking streams (drainage along Norfolk Southern's railyard in Bluefield WV to Morris Spring of East River drainage and many others).

Pseudo-Karst – an area where there is subsidence at the surface that is karst-like, and resulting surface and ground water movement occurs that is not due to natural dissolution of rock. The mined out and flooded mine pools in the Pocahontas 3 and 4 coal seams in Northern Mercer County are examples. The Northwest corner of Figure 2. shows the Pocahontas 3 outcrop highlighted in purple outline.

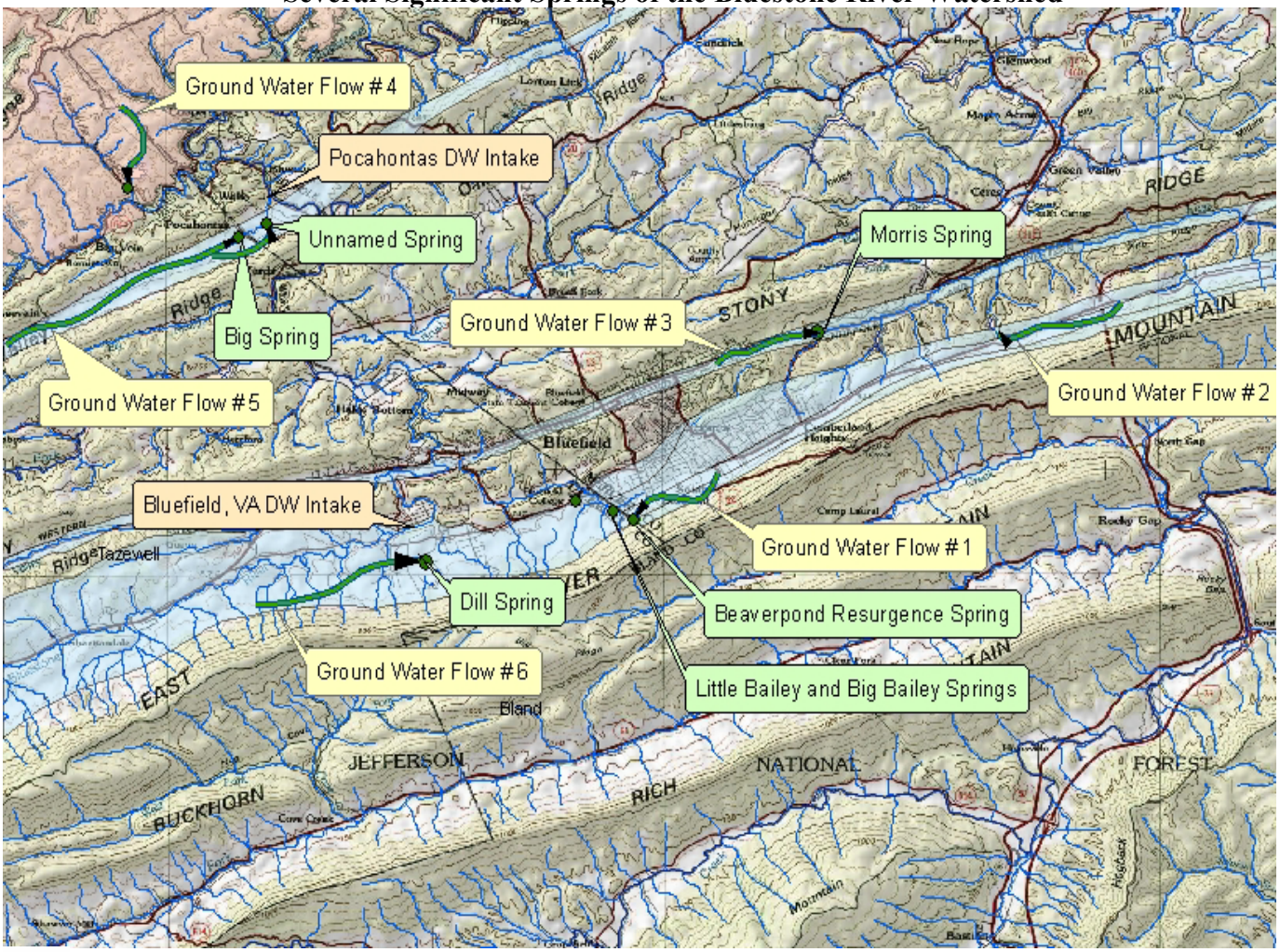
Karst Ground Water System along the U.S. Highway 460 Corridor -- Along the southern boundary of Mercer County West Virginia and eastern Tazewell County, Virginia lays a thick band of Ordovician limestones and dolostones. These rocks are over 4000 feet thick in West Virginia (WV portion of USGS map, 1963 & **LIMESTONES of West Virginia**, by J.B. McCue, J.B. Luke & H.P. Woodward, 1939. 560 pages, hard cover). In Virginia, equivalent rocks including from the base of the Beekmantown Formation to the base of the Moccasin Formation are approximately 2100 feet thick (Cooper, 1944, p. 31; Cooper, 1945, p. 67, 98-100). The St. Clair thrust fault marks the northern boundary of this belt of rocks. Rocks in this belt generally dip to the southeast; however, several splays of the St. Clair thrust fault have deformed the rocks (Cooper, 1944). This has the potential to disrupt the groundwater flow pattern.

Figure 2.


Mercer County
Groundwater Flow
Flow Arrow 4
Flow Arrow 3
Flow Arrow 2
Flow Arrow 1
N
Mercer County Caves
Poca 3 Mines
Limestone
County
Groundwater Flow Path

The field trip map (**Figure 2. Groundwater Flow of Mercer and Tazewell Counties**, Nick Schaer) shows two major groundwater flow paths in the karst area underlain by Ordovician carbonates (Balfour, conversation 2003). **Figure 2. Flow arrow #1**, near Bluefield, West Virginia along the U.S. Highway 460 corridor at the western base of the East River Mountain ridgeline, is associated with the Beacon Cave system. Beacon Cave system including Cole Hole, Beaver Pond Resurgence Spring, AEP sinkholes, Beacon Cavern Entrance (at the Bluefield Intermediate School) and Holiday Inn Hole is hydrologically connected (see Appendix A; "**Karst Groundwater Movement in the Beacon Cave System"** by Nick Schaer**)**. Beacon Cave has over four miles of mapped passage (Beacon Cave map, Original Survey 1971-1974, V.P.I Grotto; Cartography by Bill Balfour 1991; Beacon Cave, Mercer County, West Virginia; WVASS – MER.0001). Dye testing from sinkhole on AEP property next door to the Hart Electric cleanup site (also known as Joy Manufacturing cleanup site) shows that its hydrologic footprint is even larger (AEP testing; mid-1990s after cleanup was completed). Dye testing demonstrated that the dye did appear at Beaverpond resurgence in less than one day. Most water and contaminants that enter Beacon Cave system are thought to discharge at Beaver Pond Resurgence Spring just inside of West Virginia. Several other springs in the area which are smaller might be interconnected with this groundwater flow regime, but are thought not to be. These include Dill's Spring, the Big Bailey Spring and the adjacent Little Bailey Spring and are significant from the drinking water standpoint (**Figure 3, Several Significant Springs of the Bluestone River Watershed**; Green Text Boxes).

Figure 3.
Several Significant Springs of the Bluestone River Watershed



Spring or Seep

Ground Water Flow

Limestone

Coal Mined Area

Several decades ago, it has been estimated that the watershed included more than 300 legitimate users or consumers of PCB oil or equipment that used PCB oils. Three cleaned up contamination sites in Bluefield flow directly or indirectly into the Beaverpond Creek system and are documented on the EPA CERCLIS website. These sites were not considered to be sites of concern for groundwater contamination. Several other sites both in West Virginia and Virginia have been reported and are considered potential sources of the current PCB contamination. The highest PCB surface water concentration in the Bluestone River watershed to date is in Beaverpond Creek subwatershed. At the confluence with the Bluestone River, Beaverpond Creek has more than double the Virginia state standard for PCBs in surface water, 1,700 pg/L for recreational or contact, non-drinking water standard (9 VAC 25-260 - Virginia Water Quality Standards, February 12, 2004; website: http://www.deq.virginia.gov/wqs/pdf/CRITERIA.pdf).

Flow arrow #2 on the field maps (**Figures 2 & 3**), further east along the U.S. Highway 460 corridor, indicates drainage which flows into East River and was not discussed during the field trip.

Karst Groundwater System of northern Bluefield -- A belt of Mississippian Greenbrier Limestone extends southwest through northern Bluefield from Mercer County, West Virginia into Tazewell County, Virginia. The Greenbrier crops out as 1500 feet (W.Va.) to approximately 1100 feet (Virginia; Cooper, 1944, p. 155,158,161-163,166-167) of limestone that is steeply dipping to overturned. The Greenbrier limestone is the most productive cave forming carbonate in the state, although the surface features a narrow exposed karst band. The eastern half to two-thirds of the Greenbrier in western Bluefield has no surface water. The entire width and most of the length of the formation in this area is covered by Norfolk Southern Railway lines and rail yards.

Morris Spring in northern Bluefield is the largest karst spring in Mercer County (George Dasher, "**Bluefield Area Field Trip**," dated May 26, 2005; 8 p.; http://www.deq.virginia.gov/tmdl/pptpdf/bluetrip.pdf). **Flow arrow #3** as shown on the maps (**Figures 2 & 3**) comes out at Morris Spring, which flows into the East River. This ground water system travels through the Greenbrier Limestone. The entire width and most of the length of the formation is dominated by Norfolk Southern Railroad lines and rail yards.

Bluefield, West Virginia storm water drainage maps submitted for the recent MS-4 state application process indicate that surface and storm water which originate west of the Martin Luther King bridge that cross the karst area covered by the railyard, flows toward the Bluestone River. This drainage exits several pipes at the Midway RR underpass and becomes Whitley Creek, which flows shortly into the Beaverpond Creek along Virginia Avenue (U.S. Hwy 19 – Business). This confluence was previously under the Raci's Grocery store, and was recently daylighted. Looking at the surface runoff (all but non-existent along the railyard), it appears that although some of the ground water obviously becomes Whitley creek and contributes to the Bluestone River flow, the vast majority of the flow is toward the Morris Spring, **Figures 4 & 5., Storm Drain Flow #2 and Ground Water Flow #3.**

Figure 4.
Bluestone River Watershed Karst Features, Ground Water Flows, and Storm Drain Flows

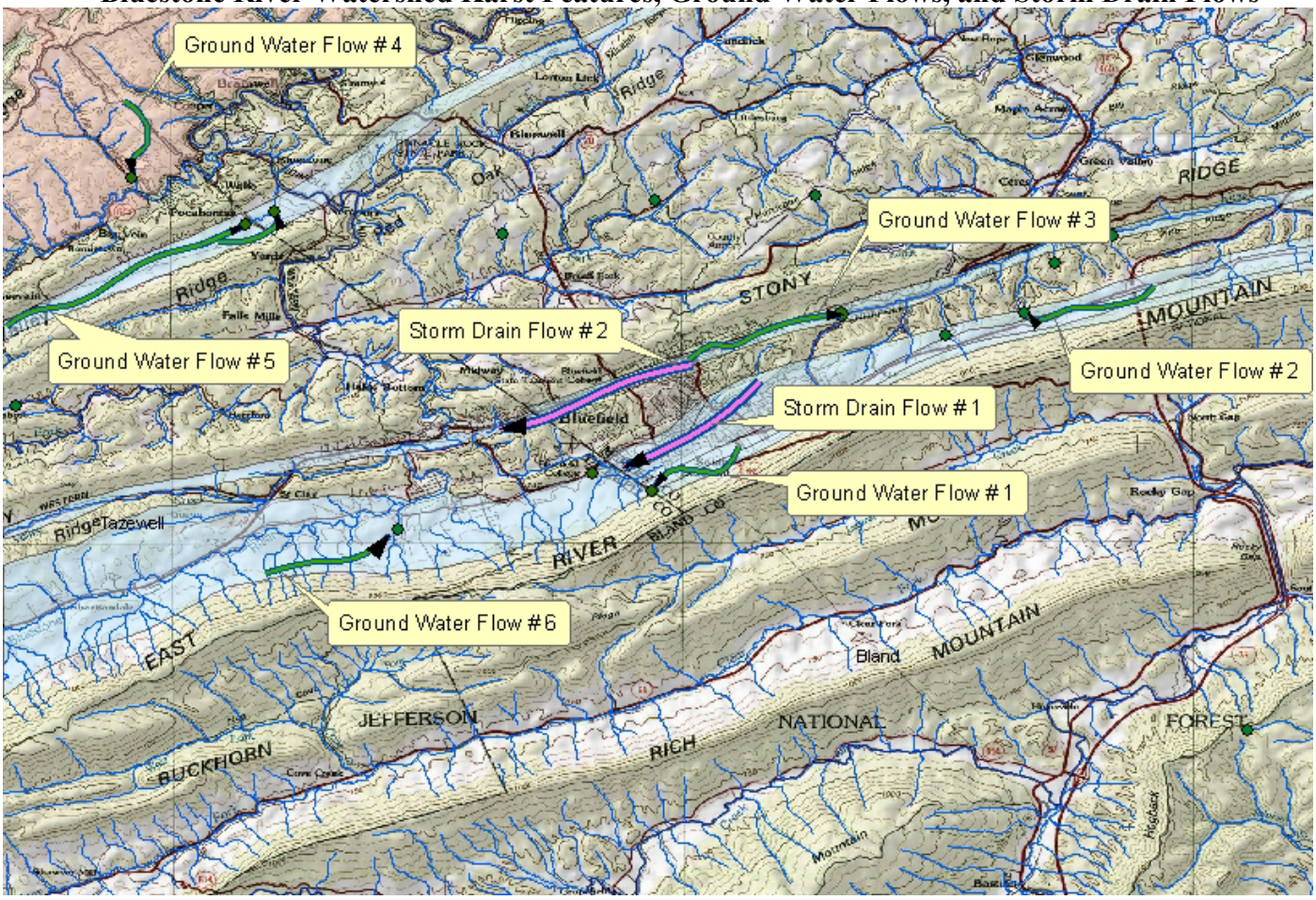
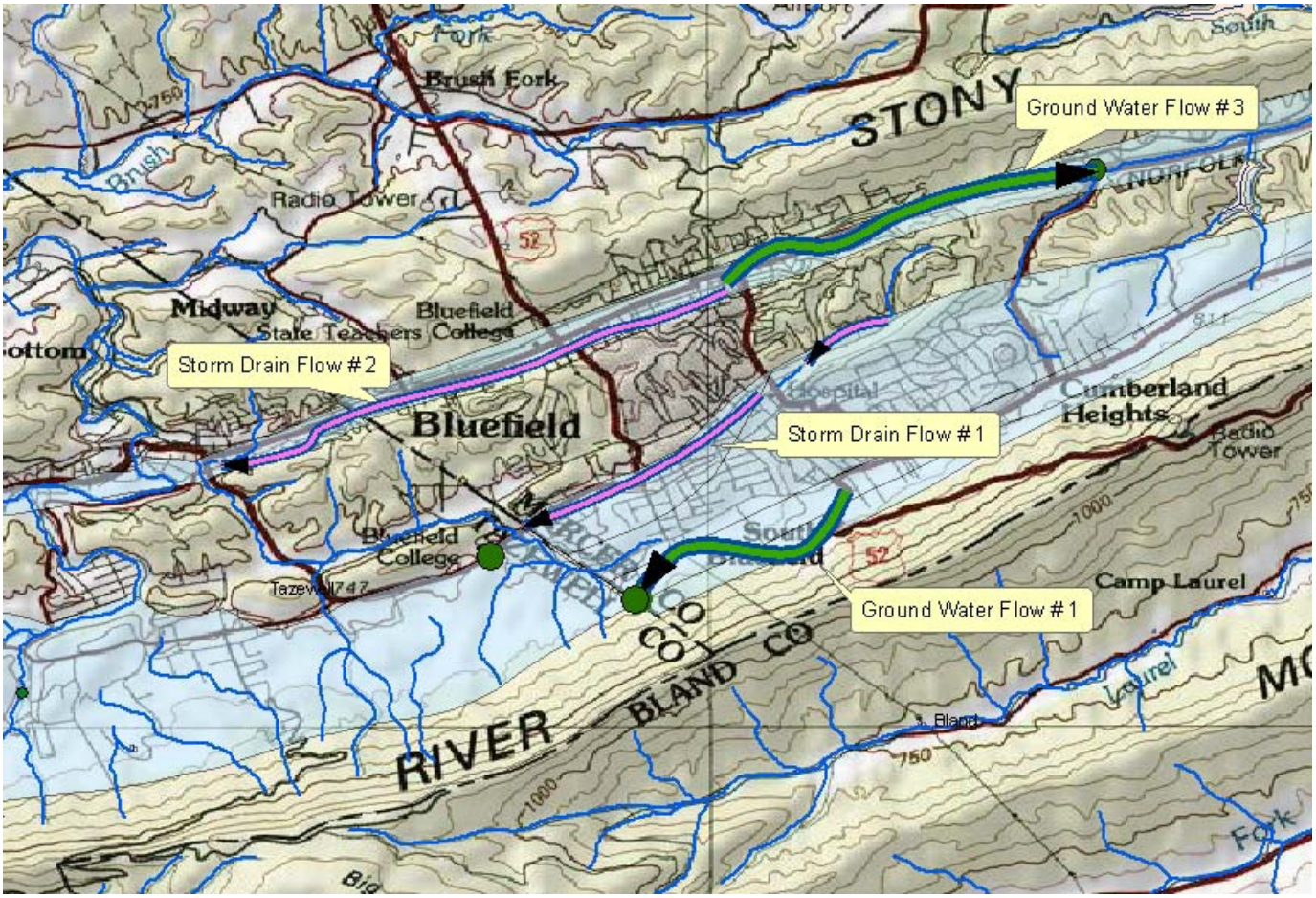


Figure 5.
Bluestone River Watershed Karst Features, Downtown Bluefield, Ground Water Flows, and Storm Drain Flows



Storm water drainage from Elmwood St. to Union St. in northern Bluefield drains down to below where Shott's Lake used to be. This lake has become a church parking lot off of Lake Avenue with an underground spring and storm water conduit. There are about 8 to 12 springs in the area that feed into this system; which also accepts drainage from a former EPA cleanup site known as the Sam and Bernard Neal families' property. There were high levels of furans/dioxins from transformer coil burning upstream near Mintwood Avenue, but no post cleanup groundwater transport effects have been monitored. This drainage area feeds into the Beaverpond Creek tributary to the Bluestone River near Bluefield College and Bluefield, West Virginia City Park.

Abbs Valley Karst Groundwater System -- Local history website: http://www.bramwellwv.com/nemours.html

Wonderful West Virginia
"Nemours: Explosive Past"

By Bill Archer

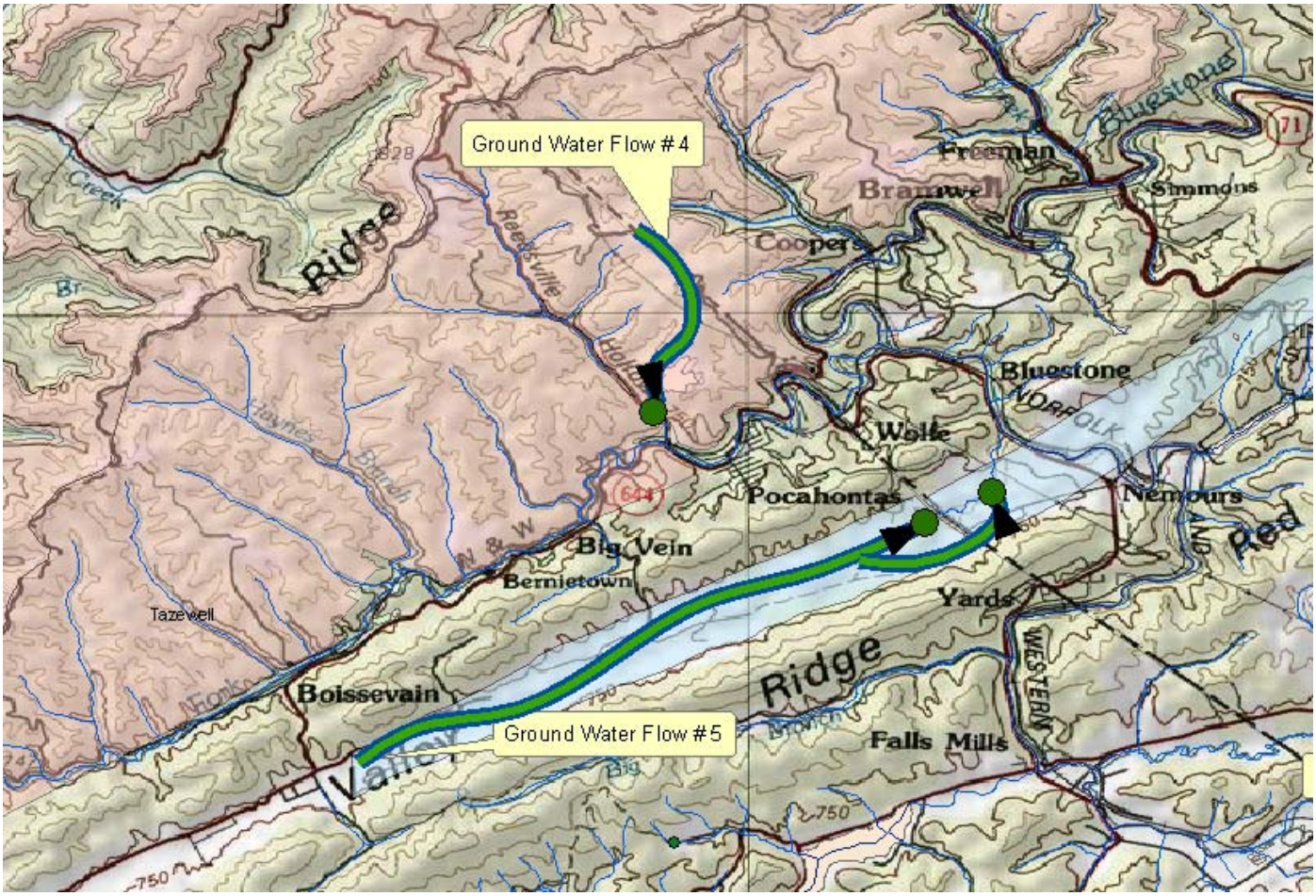
http://www.wonderfulwv.com/archives/may99/fea1.cfm

A second belt of Greenbrier Limestone crops out in Abbs Valley, near the town of Nemours. As detailed in several maps from George Dasher's presentation and notes, including the cross-section ("**Bluefield Area Field Trip**" George Dasher's handout notes' **Figures #: 1, 2, and 3**; see http://www.deq.virginia.gov/tmdl/pptpdf/bluetrip.pdf; **"Mercer County Groundwater and Karst"** George Dasher**,** 12 p.; http://www.deq.virginia.gov/tmdl/pptpdf/mercerco.pdf), Abbs Valley is a breached anticline. Despite pretty good mapping, ground water movement in Abbs Valley is not well understood. Abbs Valley contains one known PCB, Dioxin, and Furan contamination site (EPA is currently still reviewing the data and ATSDR risk assessment from Spring '04), which is very close to the intake of the Pocahontas, Virginia PSD intake. Some West Virginia households apparently receive water from this facility, also.

Big Spring is not shown as a feature of these maps, however is shown on the topgraphic maps available online at Topozone (USGS Bramwell Quad: http://www.topozone.com/map.asp?z=17&n=4128118&e=471487&s=24&size=l&u=6&datum=nad83&layer=DRG25) southwest of the state line in Virginia (Big Spring -- Lat 37° 17' 57"N; long 81° 19' 18"W (WGS84/NAD83); Pocahontas Drinking Water Intake -- lat 37° 18' 24.76"N; long 81° 18' 51.93"W NAD '83 courtesy of VDH; Contaminated Garden & soil -- 37° 17' 53"N, 81° 18' 53"W (WGS84/NAD83)) and is thought to be a higher elevation pressure release for all of the drainage from Abbs Valley. Another greater contributor to the flow of Abbs Valley River is the flow from an unnamed spring on the residential/farm property directly below the Nemours' community contamination site (it is located near the state line in WV, and appears near the yellow pentagon feature on the "Mercer County Groundwater Flow" map (**Figure 2**)). See also **Figure 6, Groundwater Flow Arrows # 4**, from Abbs Valley drainage.

Figure 6.

Bluestone River Watershed Karst Features, Pocahontas, Ground Water Flows



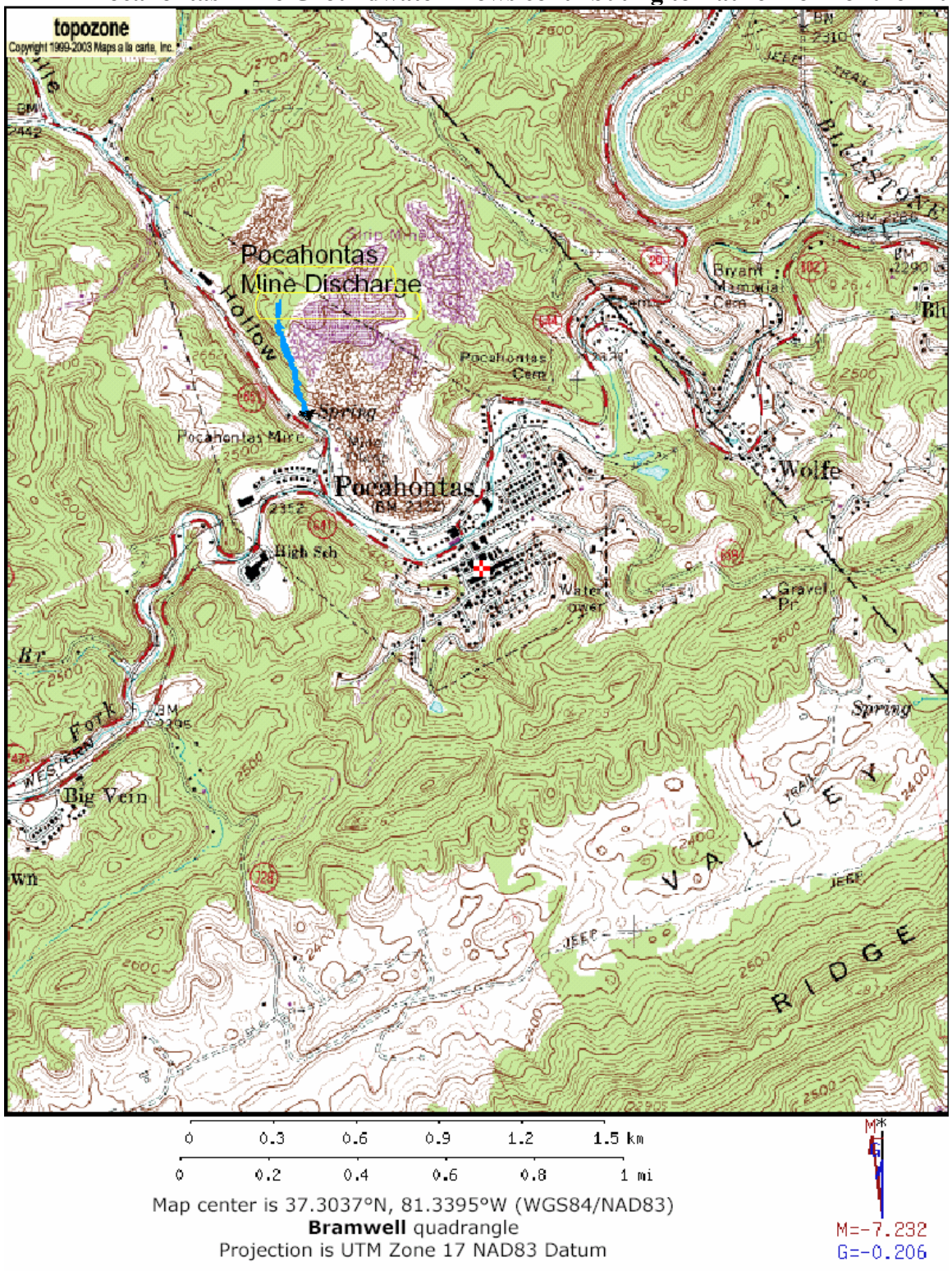
There is also a very large abandoned chemical industry complex on the banks of the Bluestone River in northwestern Nemours. The DuPont plant in Nemours, WV, produced explosives for over 50 years (see weblink to Wonderful West Virginia, above). No known chemical water quality testing has been conducted at this site. Testing is needed down stream of Abbs Valley and also in association with the PSD intake.

Pocahontas 3 & 4 Mine Pools -- In the northwest corner of the field map (**Figure 2**) are the extensive abandoned deep mines in the Pocahontas 3 & 4 coal beds. **Flow arrow #4** indicates some of the flow direction of the

discharge which appears at the outcrop of the Pocahontas #3 beds (see field maps **Figures 2 & 3, Figure 5, Groundwater Flow Arrow #5,** and map below -- **Figure 7**). These mines are very extensive and interconnected, much like the limestone cave systems to the south. It is quite possible that some PCB contamination has been abandoned in containers, spilled, or otherwise leaked into these mine voids. Large mine discharges are found just north of the town of Pocahontas, Virginia. Some of these discharges are slightly stained with red from iron associated with pyrite. It is recommended that sampling be conducted down stream of these discharges. This site was not visited during our field trip.

http://www.topozone.com/map.asp?z=17&n=4128621.00010334&e=469909&datum=nad83&u=5

Figure 7.
Pocahontas Mine Groundwater Flows contributing to Laurel Fork of the Bluestone River.



Summary: Each of these four groundwater systems is hydrologically distinct, and contributes to the flow of the Bluestone River watershed. Each of these contributions has the potential to transport PCB or other contamination into the surface water downstream. Some of these four groundwater systems affect the drinking water of surrounding communities and may either act to provide a cleaner or more contaminated source, depending upon connectivity and surface contamination sites/events.

Questions:

1. We have sampled in VA, during both high and moderate flow conditions using 30 day deployment of SPMD sampling devices to date. Will sampling the entire watershed in low flow conditions help determine the contributions from groundwater to the contaminant transport phenomenon?

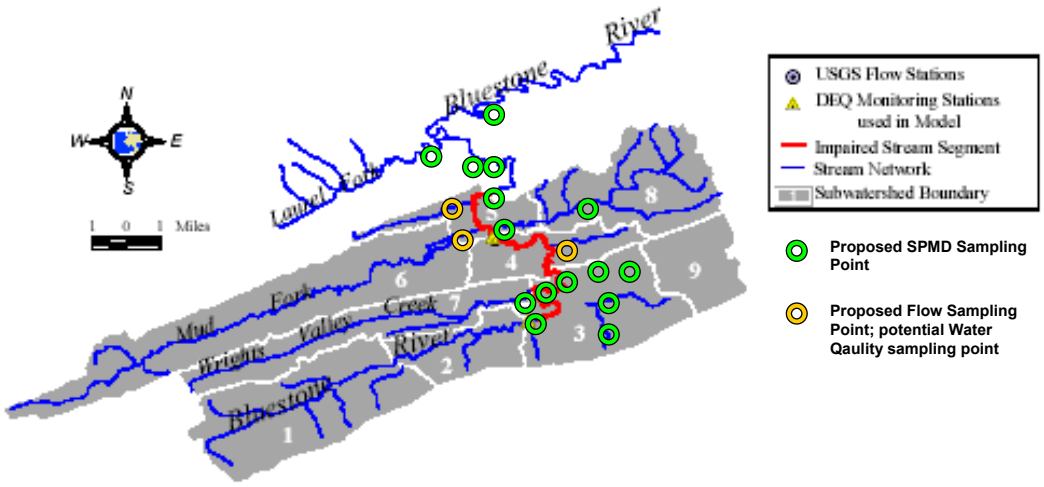
   Answer: YES.

2. The main goal of the EPA ORD RARE grant funded project, is to determine the PCB loading in order to achieve a TMDL. Is it a high priority of this study to determine the groundwater contributions in order to achieve an accurate TMDL?

   Answer: YES

3. Are the locations that are on the preliminary sampling location map (**Figure 8**, handed out during the field trip, attached below) the best sampling points based upon existing knowledge of contamination of the watershed and known PCB or Dioxin/Furan sites?

Figure 8.
Proposed Sampling Points Rare Project



Answer: Still to be determined…, feedback from the field trip and follow up, indicates that better determination in the field may be necessary to segregate karst from non-karst flow regimes. The goal will be to sample downstream of the karst beds as they cross and introduce additional waters, whether clean or contaminated, into the mainstem or tributary portions of the system. A conference call was held with Nick Schaer, George Dasher, and Craig Lott to discuss the issue, and a follow up consultation with

James Laine. It will be necessary to use existing maps of geological formations along the riverbed to pinpoint and GPS in the field the exact location of changes from limestone and dolostone (potential karst) to non-carbonate (i.e. non-karst) formations. In addition, it will be important to identify geologic structures that may affect the flow pattern, especially in the low flow sampling period.

Follow up question…How easily and accurately can these geologic transitions be delineated?

Related issues include a need for accurate karst maps or field delineation of riverbed geology. Accurate surface water flows during deployment, and consistency between the states' field measurement methods (especially flows) will also be critical.

4. What are the potential risks to water plant intakes from some of the known sites (or known contaminated tributaries) from surface/groundwater transport?

   Answer: not much discussion or feedback so far.

5. Other potential correlated studies (geologic, drinking water, other) that might help to do simultaneously or as follow up to this Bluestone River RARE project?

   Answer: One question that arose from several different sources during the field trip was that we might want to add some SPMDs underground and compare the upstream concentrations of contaminants flowing through cave system to the resurgence point concentration(s). This might support the idea that a karst system probably acts much like a pipe for these organic contaminants and 'what goes in comes out, pretty much unchanged.' Although this would be beyond the scope of the RARE project as it is currently funded, there definitely is some interest in doing this simultaneously if some additional funding were available.

   A second concern over PCBs and organic contaminant transport in DW, has been expressed by the public at meetings held for TMDLs and other watershed meetings. The concern was briefly discussed by the karst field trip group, but no conclusions were drawn of additional potential funding sources. Some of the questions might indirectly be determined using the RARE surface and groundwater PCB/dioxin watershed wide evaluation.

   Not many other specific ideas or potential other sources of funding were discussed, although there seems to be a great deal of interest from various sources so far.

References Cited

Cooper, B.N., 1944, Geology and mineral resources of the Burkes Garden quadrangle, Virginia: Virginia Geological Survey Bulletin 60, 299 p.

Cooper, B.N., 1945, Industrial Limestones and Dolomites in Virginia: Clinch Valley District: Virginia Geological Survey Bulletin 66, 259 p.

Dasher, George; "**Bluefield Area Field Trip**" (supplemental field notes compiled and distributed prior to karst field trip, 5-27-05); 2005; 8 p.; weblink: ????

Dasher, George; "**Mercer County Groundwater and Karst**"; DATE: ????; 12 p.; weblink: ????

Schaer, Andrew, George Dasher, William Whitlock; conversations, 2003-5.

Balfour, William; conversations, 2003-4.

Balfour, William; "**Beacon Cave Map**"; 1991.

Lott, Craig, Allen Newman, Nancy Norton, Roger Stewart, and Jutta Schneider; **PCB TMDL Source Assessment Study, Bluestone River Watershed**; 2004; 33 p; weblink: http://www.deq.virginia.gov/tmdl/pptpdf/blstpcb1.pdf

Archer, Bill; **Wonderful West Virginia "Nemours: Explosive Past**"; May 1999 V. 63, N. 5; Website: http://www.wonderfulwv.com/archives/may99/fea1.cfm

Schaer, Andrew; **Karst Groundwater movement in the Beacon Cave System.** 2005.

Appendix A

Karst Groundwater movement in the Beacon Cave System

Nick Schaer, WVDEP and Mercer County Karst Survey

Name	Length	Depth	Mapping	Connection	Travel Time
Holiday Hole	250	120	Yes	Probably	Unknown
KFC Cave	504	84	Yes	Probably	Unknown
Joy/AEP	Unknown	Unknown	No	Yes	Under 24 Hrs
Cole Hole	500+	50	No	Yes	Under 6 Hrs
Beacon Cave	15000	150	Yes	Yes	Under 1 hour
Beaver Pond	247	5	No	Yes	N/A

The Caves, Springs and Sinkholes list above appear to be part of a single karst groundwater system. The karst features are listed in order by groundwater flow. With Holiday Hole being the most upstream and the spring at Beaver Pond being the down stream resurgence.